SEMI-ANNUAL PROGRESS REPORT NO. 16

May 1, 1981 to October 31, 1981

NASA Grant NGL 25-001-054

Submitted To

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Space and Terrestrial Application
Technology Transfer Division
Washington, D. C.

Submitted By

W. Frank Miller*
Jon R. Clark
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Brian Duffy
Karen Minchew
Linda H. Wright

MISSISSIPPI STATE UNIVERSITY
P. O. Drawer FD
Mississippi State, MS 39762

November 1, 1981

***Director, Mississippi Remote Sensing Center**

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APPLICATION OF REMOTE SENSING TO STATE AND REGIONAL PROBLEMS

I. INTRODUCTION

The major purpose of the Remote Sensing Applications Program is to interact with units of local, state, and federal government and to utilize Landsat data to develop methodology and provide data which will be used in a fashion such that a concrete, specific action will be taken by the cooperating agency. The attainment of this goal is dependent upon identification of agency problems which are immediate in nature, and subject to at least partial solution through the use of remotely sensed data.

Other subsidiary objectives include the development of a trained staff from the faculty of Mississippi State University who are capable of attacking the varied problems presented by the respective state agencies; the training of students in various University academic courses at both the undergraduate and graduate levels; the dissemination of information and knowledge through workshops, seminars, and short courses; and the development of a center of expertise and an operational laboratory for training and assistance to cooperating agencies.

II. GENERAL PROGRAM PROGRESS

One of the major accomplishments of the past six months has been the formalization of automatic data processing support. The Data General minicomputer was moved to facilities of the Remote Sensing Center, and consequently is now totally dedicated to applications by the staff of the Center. Ms. Karen Minchew accepted a half-time Research Associate position in software development, and Mr. Asif Khan, formerly a graduate assistant at the University of Tennessee Space Institute, begins work on November 1 as a Research Associate in Remote Sensing Applications. Mr. Khan will eventually assume responsibility for the bulk of the data processing operation. A Matrix Sequential Camera System has been purchased with state support monies to enhance our graphic capabilities, particularly with respect to real-time graphic products for the user community. State support has also provided a second Numonics digitizer which will be used as backup in heavy work load periods, or as replacement during down time on the original digitizer.

A quarterly newsletter series was initiated in September, and was well received by the user community. Numerous requests for information on program capabilities have been received. A copy of the first issue of Scanlines is included with this report.

The software which was developed to track animal locations (Section D, page 14, Semi-Annual Report No. 15) was successfully utilized in an operational sense, and part of the application was reported in a recent Master's thesis (Appendix I).

III. PROJECT PROGRESS REPORTS

A. Remote Sensing Applications in Land Use Planning - Lowndes County

Objective

To develop a Landsat-based data management system that will provide variables and data which can be used by the County Tax Assessor, the Civil Defense Director, and the Lowndes County Board of Supervisors, and for employment in the land use planning function by the Golden Triangle Planning and Development District and the Mississippi Research and Development Center.

Accomplishments

The Lowndes County information system is utilized as the basic demonstration of system capabilities to the various individuals and groups who tour the facilities of the Center. A portion of the data base is also being used to develop a prototype tax information system (Section D). Other than the indicated uses, no utilization by Lowndes County officials has occurred during the past six months.

Current Status and Plans

Work with the tax data base concept will continue, and an updated land cover analysis of the County will be performed upon receipt of suitable Landsat data.

B. Applications of Landsat Data to Strip Mine Inventory and Reclamation

Objective

The objective of this project is to provide the Alabama Surface Mining Reclamation Commission and the Geological Survey of Alabama with the software and interpretative techniques for monitoring strip mine occurrence and reclamation activities. The results will also be provided to the Mississippi Geological, Economic, and Topographic Survey, the State agency which is responsible for administering the surface mining law in Mississippi.

Accomplishments

Data of adequate quality has not become available during the past six months and, consequently, this project has remained inactive.

Current Status and Future Plans

Due to increased NASA (Earth Resources Laboratory, NSTL) interest and involvement in this area of work, this project has been terminated.

C. White-Tailed Deer Habitat Evaluation Using Landsat Data

Introduction

In order to provide a basis for sound natural resource management in Mississippi, the Mississippi Department of Wildlife Conservation has initiated the development of a state-wide data base system which will be used to describe various components of Mississippi's ecosystems. The high priority of the white-tailed deer (*Odocoelius virginiana*) in the Department's management policies dictates that various types of deer "habitat" be mapped and evaluated on a state-wide basis. These "habitats" will be delineated on the basis of several biophysical variables.

Because of its synoptic and temporal characteristics, Landsat multispectral scanner (MSS) data will be used as the basis for vegetative classification. Both supervised and unsupervised classification of the data will be performed to determine the most accurate and the most cost-effective means of mapping vegetation. Other variables used to evaluate deer habitat will be compiled from existing sources. All data will be configured in a computer-assisted data base to facilitate rapid and accurate habitat evaluation.

Objectives

The project's objectives, in order of planned completion, are:

1. to determine those types of vegetative associations which are of significance in managing Mississippi's white-tailed deer.
2. to determine which of several analytical procedures are

most effective in detecting these vegetation types using Landsat MSS data.

Accomplishments and Current Status

Automated analysis of digital MSS data sets for the Choctaw and Leaf River study areas has been completed. A clustering algorithm was used to obtain the spectral signatures for land cover types, and a nearest-neighbor algorithm was used to classify pixels for each study area. These classified data are being kept on magnetic tape while the accuracy of the classification effort is determined. As this is a demonstration project, it has been decided that accuracy be determined by visually comparing test plots in the classified data with aerial photography and field work conducted by MRSC personnel. Comparisons are conducted using the display capabilities of the MRSC's Data General minicomputer.

Topographic data has been obtained from the USGS "NCIC Digital Terrain Data" tapes. These raster-type data sets of elevations are being processed into Elevation, Slope, and Aspect data sets using an algorithm developed at MRSC. Elevation, slope, and aspect data sets are being prepared for loading into all three wildlife habitat data bases.

The Choctaw and the Leaf River data bases are both 80 percent completed. Full completion of both data bases awaits the loading of final land cover data sets and data for each of the three topographic features.

Future Plans

The following tasks have been established as goals for the

next reporting period:

1. Accuracy determinations will be completed for classified MSS data for the Choctaw and Leaf River areas. If accuracy is 85 percent or better, the data will be loaded to the appropriate data base. If accuracies are below 85 percent, new image classification efforts will be initiated.
2. Processing of digital topographic data will continue for all three study areas. Loading of these terrain features data into the Choctaw and Tallahala data bases should easily be accomplished during this period. Digital topographic data for the Leaf River study area originates on two separate NCIC data tapes. Merging these data may cause some delays in loading topographic feature data in the Leaf River data base.
3. Several exemplary output products from the data bases will be prepared to illustrate the utility of the data base approach to the potential user community. Map-type products, acreage summaries, and some user-oriented documentation on data base construction and operation will be forwarded for review to the following potential users:

   MSU Department Wildlife and Fisheries
   Mississippi Department Natural Resources
   Mississippi Department Wildlife Conservation
   U. S. Fish and Wildlife Service, Jackson, MS.

D. Remote Sensing Data Analysis Support Systems

Objectives

Concurrently with development of new software capabilities at the Center, much existing software for the creation and management of geographic information systems has been enhanced, documented, and prepared for "downloading" to a micro-computer system. This means that algorithms to perform specific tasks have been modified to make minimal demands on core storage and I/O sophistication, in order to keep the cost of a fully implemented micro-system within a range accessible to county level governments. User fault tolerance has also been improved in much of this software.

New software developed at the Center is best described in terms of individual projects; development has generally been in response to a known need for a given capability.

Accomplishments and Current Status

In order to expand the MRSC's capabilities in the image analysis area, several task areas have been initiated. Two new digital sensor-type data sets and two new image analysis algorithms are being investigated.

Digital data sets from the SEASAT Synthetic Aperture Radar (SAR) and from the NASA Thematic Mapper Simulator (TMS, Aircraft Monitor package) have been obtained. These data sets are now being processed into formats compatible with image analysis algorithms presently operational at MRSC. Plans are being developed for using either TMS and SEASAT-SAR data individually in image analysis efforts or combining

them with LANDSAT MSS data during analysis. The intent of this effort is to gain experience in working with data set types which will be available from the LANDSAT-D satellites (the TMS data), or which will introduce new data channels into land cover mapping tasks (the SEASAT-SAR data).

The two image analysis algorithms being explored are stratification of an MSS digital data set by ecological zones, and improvement of image classification by addition of a topographic data channel. In connection with a contract project in Puerto Rico, a MSS data set is being geographically split into segments representing pre-defined ecological zones. The rationale for this is that different ecological zones contain different vegetative communities, and that there is a high likelihood that two different communities in two different zones may have very similar reflectivity characteristics. If image classification was conducted on pixels from both life zones together, two communities might be spectrally confused. By stratifying the MSS data prior to classification, however, the pixels of different ecological zones are statistically separate during image classification which presumably will facilitate a more accurate land cover mapping effort.

A project has been undertaken by the Center to map a county tax assessor's land ownership files into a computer-based geographic information system. Development of the software to accomplish this end has taken two different approaches. One approach is being developed on the Data General S/130 minicomputer and is based on

the design of an in-house prototype polygonal database for storage of landowner parcel maps, soil type maps, and land cover classification maps. This interactive software package includes the following: 1) Routines for the construction and maintenance of the database; 2) Routines to reference a particular landowner and classify acreage within the landowner parcel according to land cover classification and soil type; 3) Routines to utilize this acreage classification information along with a set of tax rate tables to calculate tax dollar amounts; 4) Routines to obtain a video display of the land parcel map and also any textual legal descriptions and documents associated with it.

This polygonal approach has three major advantages that make it a very viable solution to this particular application, in addition to implications for applicability in other areas in the future. The most important of these advantages is the flexibility of resolution size inherent in the system. Cell resolution size is an input to the program and is therefore determined strictly by the user. The second advantage found in this approach is that this system is being developed on a relatively small machine. This is being done with a view toward the system eventually being a feasible acquisition for tax assessors with similar equipment. The third advantage of this software system is that it is self-contained. This system is not dependent on a larger machine for construction and maintenance of the data base as has been the relationship in the Data General being dependent upon the Univac 1100/80 for

maintenance routines.

The polygonal approach to the landownership application has been determined to be a very compatible and viable approach. Many routines in the package have already been implemented. Others have been developed but not yet implemented. Plans for the future include continuation of implementation and refinement of this software package. However, work on the project has been temporarily halted until further funding is available.

The second approach to this problem utilizes existing software which create and maintain geographic information system (G.I.S.) data bases. The contents of the G.I.S. data base is adjusted to maintain not only the X-Y coordinates of pixels, but to also contain a unique hashing code which identifies the individual who owns that particular pixel. The hash code is merely some unique number which can be derived in several ways, determined by the eventual user. It is used as the sole identifier throughout the rest of the software package. Of course, all of the calculations and output described in the previous approach can be done here, with the exception of video displays. At present time, the output is limited to the Univac 1100/80 high speed printers and its supporting terminal network.

Some of the characteristics of this package are that any variable class in a data base, not just soils and land cover, may be cross-tabulated with any type of record data; secondly, the existence of the hash code identifier is in no way bound to land ownership. Any legal or administrative map unit may be digitized and used as

a search key to locate records (written) related to that map unit. The prototype for this approach has been completed and is currently operational.

Additional data channels consisting of topologic features are being considered. Digital terrain tapes from the U. S. Geologic Survey are being processed into data sets of elevation, slope, and aspect. Present activities are concentrating on reformatting these data into digital files compatible with MRSC's image analysis algorithms.

Future Plans

The following tasks have been established as goals for completion during the next reporting period:

1. Initial efforts with the classification of SEASAT-SAR, and TMS data will be conducted. Digital data sets will be analyzed separately and in conjunction with LANDSAT MSS data to determine the utility of these new data.
2. Digital topographic data will be combined with LANDSAT MSS data in an effort to enhance the accuracy of computer-assisted digital image analysis.
3. Work will continue on combining and documenting several major separate image analysis/geo-data base programs on the Data General (DG) System.
4. The image splitting and reassembly procedures will be pursued, also on the DG System.

E. Landsat Change Discrimination in Gravel Operations

Objectives

The major objectives of this project were: (1) the development of computerized concepts and methodologies that will allow the user to effect temporal change detection in the extent of gravel mining operations using Landsat MSS data; (2) to apply these concepts in a change detection analysis on a portion of the Loessial Bluffs in north central Mississippi.

Accomplishments

Landsat data from an April 1980 overflight were obtained, and the procedure outlined in Semi-Annual Report No. 15 was followed. A final report prepared for the Mississippi Mineral Resource Institute (MMRI) is in manuscript form.

Current Status and Future Plans

This project has been terminated, but communication with the Director of the MMRI will be continued, and support provided if requested by that agency.

F. Discrimination of Unique Forest Habitats in Potential Lignite Areas in Mississippi

Objectives

The principal objectives of this project were: (1) to develop practical and cost-effective methodologies using Landsat and aircraft data to discriminate areas of relatively undisturbed old growth hardwoods within Mississippi's lignite belt; (2) to identify and map such areas and provide this information to botanists employed by the Mississippi Natural Heritage Program (MNHP); and (3) to incorporate various attributes; i.e., hydrology, soils, and land cover of the lignite belt into a digital geographic information system (GIS) that will facilitate the management of the accumulated data of the study area.

Accomplishments

The objectives were achieved, and a final report was prepared. This report is included as a separate item.

Future Plans

This project has been terminated.

G. Discrimination of Freshwater Wetlands for Inventory and Monitoring

Introduction

Concern over the destruction of the nation's wetland resources is currently in the forefront of environmental issues. Their value as a protection to other ecosystems has only recently been recognized, as well as their concomitant value in supporting unique plant and animal species themselves. Although many studies have been conducted, laws passed, and classifications systems established, there are still many large gaps in knowledge which need to be filled.

The official wetlands classification system currently being used by U. S. Government agencies is the U. S. Fish and Wildlife Service's Classification of Wetlands and Deepwater Habitats of the United States. This system was designed for use on a nationwide basis, and is therefore necessarily very general in character; hence it is of limited value on an area or local scale. The Mobile Corps of Engineer District has expressed a need for, and interest in developing a system that would be more closely correlated to unique local and area conditions.

Objective

The objective of this proposed study is to develop remote sensing techniques, utilizing aerial imagery and satellite data, for delineating freshwater wetland types with increased accuracy and decreased intensity of on-site inspection.

Methods and Procedure

Since the last reporting period, this study has been expanded to include three major physiographic regions in Mississippi: (1) the Upper Coastal Plain, (2) the Lower Coastal Plain, and (3) the Mississippi River Delta. Okatibbee Lake will still be used as a model for the Upper Coastal Plain. Parts of the Delta National Forest will be used as a model for the Mississippi River Delta physiographic region, and the Pearl River alluvial plain in the vicinity of the National Space Technology Laboratories will be used for modeling in the Lowel Coastal Plain fresh water wetlands. The general procedures for analyzing the Landsat data will not be changed.

In addition, an attempt will be made to develop a general wetlands "crop calendar" for the three physiographic regions. This will be accomplished through literature research, the aid of wetlands ecologists/biologists familiar with the areas, and field surveys. The crop calendar should be helpful in identifying with reasonable accuracy the probable major plant associations in a given physiographic region for a given time period, and therefore should be useful in determining their spectral signatures from Landsat analysis.

Accomplishments

Field trips have been made to the Delta National Forest and Okatibbee Reservoir to locate and describe vegetation communities. Data sheets have been developed to aid in the collection of data from wetlands specialists. Computer compatible tapes (CCTs) have been ordered for the Delta National Forest and the Pearl River areas; no data of acceptable quality was available for all three areas in

the past three years, and therefore, 1978 data will be used. Thematic Mapper (TM) data of the Pearl River study area was requested and received from NASA/ERL, and is in the process of being reformatted for compatibility with the EOD/LARSYS software package. It will be compared to Landsat data of the same area.

Future Plans

Within the next three months, CCTs should be in hand at which time graymapping, training site selection, and ISOCLAS analysis can proceed. Also TM data reformatting should be completed and ready for analysis. Further field trips will be made as required, and assimilation of crop calendar data will proceed concurrently with other activities.

H. A Conceptual Design For A Landsat-Based, State-Wide Information System

Introduction

The Supreme Court of Mississippi has directed that the Mississippi Tax Commission (MTC) shall, beginning with the 1983 tax rolls, base all appraisals on a uniform basis throughout the state. This decree, later enacted as various sections of the Mississippi Code, has raised formidable problems in the areas of data handling and annual assessment of property.

Personnel of the Mississippi Remote Sensing Center (MRSC) have been concerned with these problems for some time, and have worked closely with MTC Equalization Division personnel to develop concepts for data management and land cover analysis. Concurrently with these efforts, it was determined that the State has been moving ahead with plans for a state-wide telecommunications network under the provision of HB 1062, which provides for on-line processing of vehicle registrations. Preliminary discussions between the Central Data Processing Authority (CDPA), the state agency responsible for the technical aspects of the system, MTC, and MRSC personnel have indicated the possibility of developing the system into a resource information system which includes the data necessary for taxation purposes.

Objective

The objective of this project is to determine the feasibility of using Landsat digital data as a means of acquiring annual changes in land cover on a state-wide basis, and integrating the land cover

change into a data management system which will be accepted by the proposed state-wide telecommunications system.

Accomplishments

A portion of the Lowndes County Information System was selected and redigitized with a one-acre cell resolution. Input data were parcel (ownership) boundaries, township, range and section lines, soil mapping units, and Landsat-derived land cover. As indicated in Section D, appreciable progress has been made in software development. Progress, specifically in the raster-based approach, is illustrated by the series of illustrations which follow.

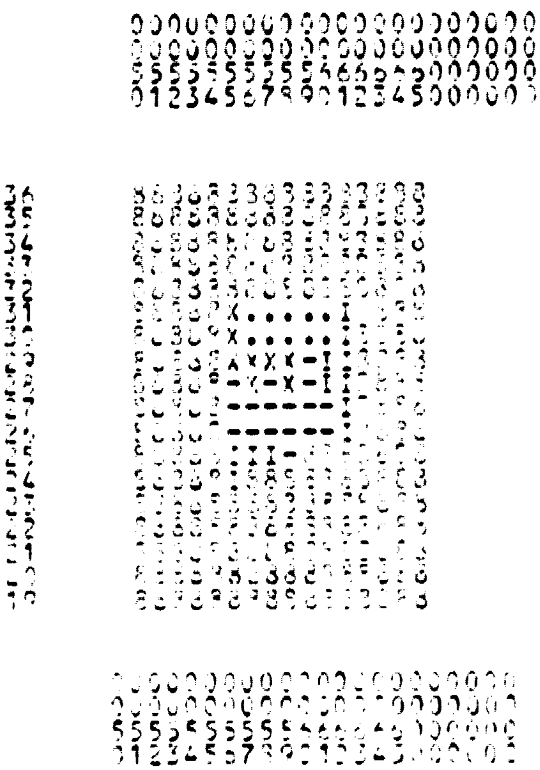
Figure 1 represents the variable outputs of soil and land cover for a parcel owned by "Bobby Smith." The tabular presentation represents the summary of parcel acreages by land cover types and soil mapping units. Internal to the program is a lookup table applicable to the state which lists all soil mapping unit designations and the productivity rating for the respective land uses. Another lookup table is also internalized, but on a county basis; this table gives the respective per-acre use values by use and productivity level. The acreages and values are merged into a final tax value table (Table 1).

Future Plans

Software development efforts will continue as indicated in Section D. One county which has already undergone re-appraisal under the new statute will be selected for a Landsat-based land cover analysis. The results of the land cover analysis will be compared to the land cover determinations of the local tax assessor.

Figure 1. Calculation of Taxes Due on Land Owned by Smith, Bobby, Performed by Mississippi Remote Sensing Center.

Soil Mapping Units



Land Cover

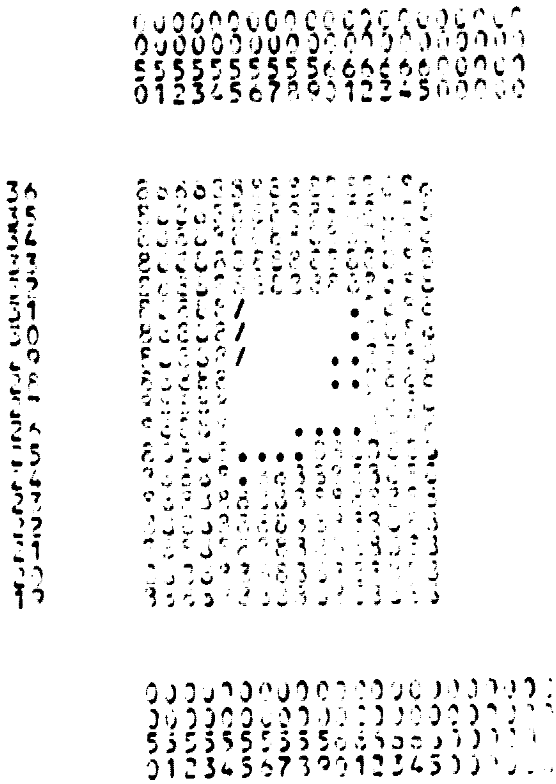


Figure 1 - Continued

L A N D C O V E R

		0	1	2	3	4	Total Acres
	0	0	0	0	0	0	0
S	1	10	0	0	0	0	10
O	2	13	4	0	0	0	17
I	3	0	0	0	0	0	0
L	4	0	0	0	0	0	0
S	5	1	11	0	0	0	12
	6	0	0	0	0	0	0
	7	5	0	0	0	3	8
	8	0	0	0	0	0	0
Total Acres		29	15	0	0	3	47

Where:

Soil Classes

0 Void
1 VAA, Sub2, SE, KPB2, VAB2
2 CU, CBA, LB
3 VAC2
4 OKA, OKB, BRB
5 GY, ST
6 PT
7 LE, JM, MA, CP
8 SUC2, SVD3

Land Use:

0 Agriculture
1 Hardwood
2 Pine
3 Water
4 Other

Table 1. Tax Evaluation for Smith, Bobby. (In Dollars)

	LANDCOVER 0	1	2	3	TOTALS
S 1	.00	.00	.00	.00	.00
O 2	37.95	28.16	.00	.00	66.11
I 3	147.42	3.12	.00	.00	150.54
L 4	5.00	.00	.00	.00	5.00
TOTALS	190.37	31.28	.00	.00	221.65

Total Taxes Due: $221.65

The following is a descriiption of the land owned by Smith, Bobby:

Any type of legal description (or mere text) may be inserted here.
The text is stored in a file and can be printed whenever it is needed.
There are as many text blocks as there are parcels in this county.

* * * * End Job * * * *

IV. LIST OF SPECIAL ASSISTANCE OFFERED

Technical Advice or Publications Supplied

Mr. Frank Shropshire, USDA, Forest Service, Jackson, MS

Mr. Dave Shore, USDA, Forest Service, Ackerman, MS

Mr. Charles Blalock and Staff, MS Department Natural Resources, Jackson, MS

Mr. Carl Mason, MSU Department of Wildlife and Fisheries

Dr. Ed Hill, Mississippi Cooperative Wildlife and Fisheries Research Unit, U. S. Fish and Wildlife Service

Mr. Steven F. Miller, Gilbert-Commonwealth, University of Maryland

Mr. Bob Parker, Private Forestry Consultant, Starkville, MS

Dr. Ernie Gluessing, MSU Department of Wildlife and Fisheries

Dr. Jerry E. Vardaman, Cobb Institute of Archeology, Mississippi State University, MS

Messrs. Rayford Williamson and Dwight Monday, Mississippi State Forestry Commission

Mr. Oz Ellis, Lowndes County Civil Defense Office, Columbus, MS

Dr. Tom Sever, Data Preparation, Lockheed Engineering and Management Services, NSTL, MS

Mr. J. F. Vengrouskie and Mr. Ken Tobala, Gulf States Paper Company, Tuscaloosa, AL

Mr. Jim Cleveland, Director, Information and Promotional Material, MFC Services, Madison, MS

Mr. E. R. Coley, Champion Timberland, Russelville, AL

Dr. T. J. Karamanski, Loyola University of Chicago

Mr. Carleton Owen, Supervisor, Environmental Affairs, Potlatch Corporation, Warren, AR

Dr. Irwin Schollar, Director, Laboratory for Field Archeology, Bonn, Germany

Demonstration and Educational Activities

Dr. George Switzer, MSU Department of Forestry

Mr. Tom Terry, Weyerhaeuser Corporation

Mr. Ian Sutherland, Alberta Remote Sensing Center

Mississippi Farm Bureau, Forestry Committee

Mr. Jack Pitcher, USDA, Forest Service Seed Laboratory, Starkville, MS

Mr. Nick Rouse, Eastern Energy and Land Use Team, Kearneysville, W. Virginia

Mr. Ron Black, Molpus Lumber Company

Mr. Richard Birdsey, USDA, Forest Service, New Orleans, LA

Mr. George Kimani, Deputy, Director, Ministry of Agriculture, Government of Kenya

Professor R. S. Musangi, Principal, Egerton College, Njoro, Kenya

Mr. Kiali Mwendwa, Chairman, Board of Directors, Egerton College, Njoro, Kenya

Dr. Huey Battle, A Vice-President, Virginia State University and Home Campus Coordinator for Training for the project

Messrs. George Paris, Carl Ragus, Bruce Baldwin, USDA, Forest Service, Jackson, MS

High School Senior Math Students, Caledonia, MS

APPENDIX I

ABSTRACT

Seth Evans Mott, Master of Science, 1981.

Major: Wildlife Ecology, Department of Wildlife and Fisheries

Title of Thesis: Movements and Habitat Use by White-Tailed Deer in a Bottomland Hardwood Area of Mississippi

Directed by: Dr. David C. Guynn, Jr., and Dr. Harry A. Jacobson

Pages in Thesis: 54.   Words in Abstract: 132.

ABSTRACT

Ten white-tailed deer (*Odocoileus virginianus*) were outfitted with radio-collars to monitor seasonal movements and habitat utilization. Four juvenile deer were lost early in the study due to dispersal or collar loss. Six adult deer were radio-tracked for a 12-hour period every fifth day for 1 year. Three adults moved distances greater than 3 km but always returned to previously occupied areas. Varying amounts of home range shift were observed in all adult deer. Estimates of seasonal home-range size ranged from 266 ha to 2120 ha using the multivariate Ornstein-Uhlenbeck process. Deer locations were combined with a digital habitat data base to analyze habitat use. Utilization/availability analysis indicated that deer prefer mature bottomland hardwoods

and open pine plantations year-round. Some deer appeared to expand their home range to exploit soybeans during the growing season. Theories concerning reasons for the large home-range sizes and the seasonal shifts in home range are presented.

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INTRODUCTION

Bottomland hardwood forests once covered extensive areas of the Mississippi delta and other riparian environments throughout the Southeast. These bottomlands have been generally recognized as excellent wildlife habitat. They have supported high densities of white-tailed deer (Odocoileus virginianus) (Moore et al. 1960, Moore 1967, Murphy and Noble 1972), producing more deer food per unit area than any other Southeastern forest type (Stransky 1969). Since 1960 much of this unique habitat has been converted to land uses more economically lucrative than timber and wildlife production (Stransky and Halls 1968, Holder 1970). In 1971 the U. S. Department of Agriculture reported that up to 81,000 ha of bottomlands in the lower Mississippi valley were converted to agriculture each year. Few studies, however, have examined the impact of the loss of bottomland areas on white-tailed deer or the role of the remaining bottomland hardwoods in deer ecology.

In some areas, 90% of cleared bottomlands have been converted to soybean production (Holder 1970). Comparative deer utilization of these croplands and remaining natural vegetation has not been adequately investigated. Depredation reports of state wildlife agencies

have documented summer deer use of soybean fields (Moore and Folk 1978). Murphy and Noble (1972) found deer used soybeans extensively from the time beans sprouted until harvest waste was disked under. Zwank et al. (1979) reported that deer concentrated in bottomland forests after harvest of nearby agricultural lands. Whether deer use soybeans and other crops as a supplemental food and/or cover source, or have become dependent on these areas in the absence of natural vegetation is not known. The management and economic implications of this question become more important as larger areas of bottomlands are converted to agriculture and as deer damage to crops increases.

It has been generally assumed that deer in the Southeast are sedentary, with home ranges of less than 259 ha (Michael 1965, Hood 1971). Although some variability in home range due to changes in food supplies has been documented (Marchington and Jeter 1966, Michael 1965, Byford 1969), reports of major home range shifts in response to changing food supplies have been limited. If the effects of bottomland forest conversion to agriculture on deer populations are to be understood, more data are needed on deer movements and habitat preferences in areas where croplands, bottomland hardwoods and other vegetative types are juxtapositioned. This study examined deer use of bottomlands and adjacent habitat types with 2

major objectives:

1. To determine the utilization of bottomland hardwood forests by white-tailed deer relative to other habitat types.

2. To determine the movements of white-tailed deer between bottomland hardwood forests and agricultural areas.

DESCRIPTION OF STUDY AREA

The study area was located in Noxubee County, east-central Mississippi (Fig. 1). The area lies at the junction of the Black-belt Prairie and the Tombigbee River flood-plain. Climate is characterized by hot summers and cool, moist winters. Average winter temperature is 13.5° C, while summer temperatures average 26.5° C. Average yearly precipitation is 139 cm (Brent 1979). The summer of 1980 was abnormally hot and dry.

The core of the study area was a private holding of 2025 ha in Bigbee Valley, MS with limited, well-controlled access. A system of dirt and gravel roads extends throughout the study area. Foot plots (corn, rye, wheat and turnips) are interspersed along the road system. Adjoining lands are used primarily for soybean and cattle production. The forested portion of the area is managed for wildlife and timber resources.

An important aspect of the study area is its habitat diversity. Dominant vegetative cover types of the area are pine (10%), mixed pine-hardwoods (6%), bottomland hardwoods (44%), tupelo-cypress (1%), pasture (17%) and row crops (11%). Non-vegetative land cover (11%) includes residential sites, roads and open water.

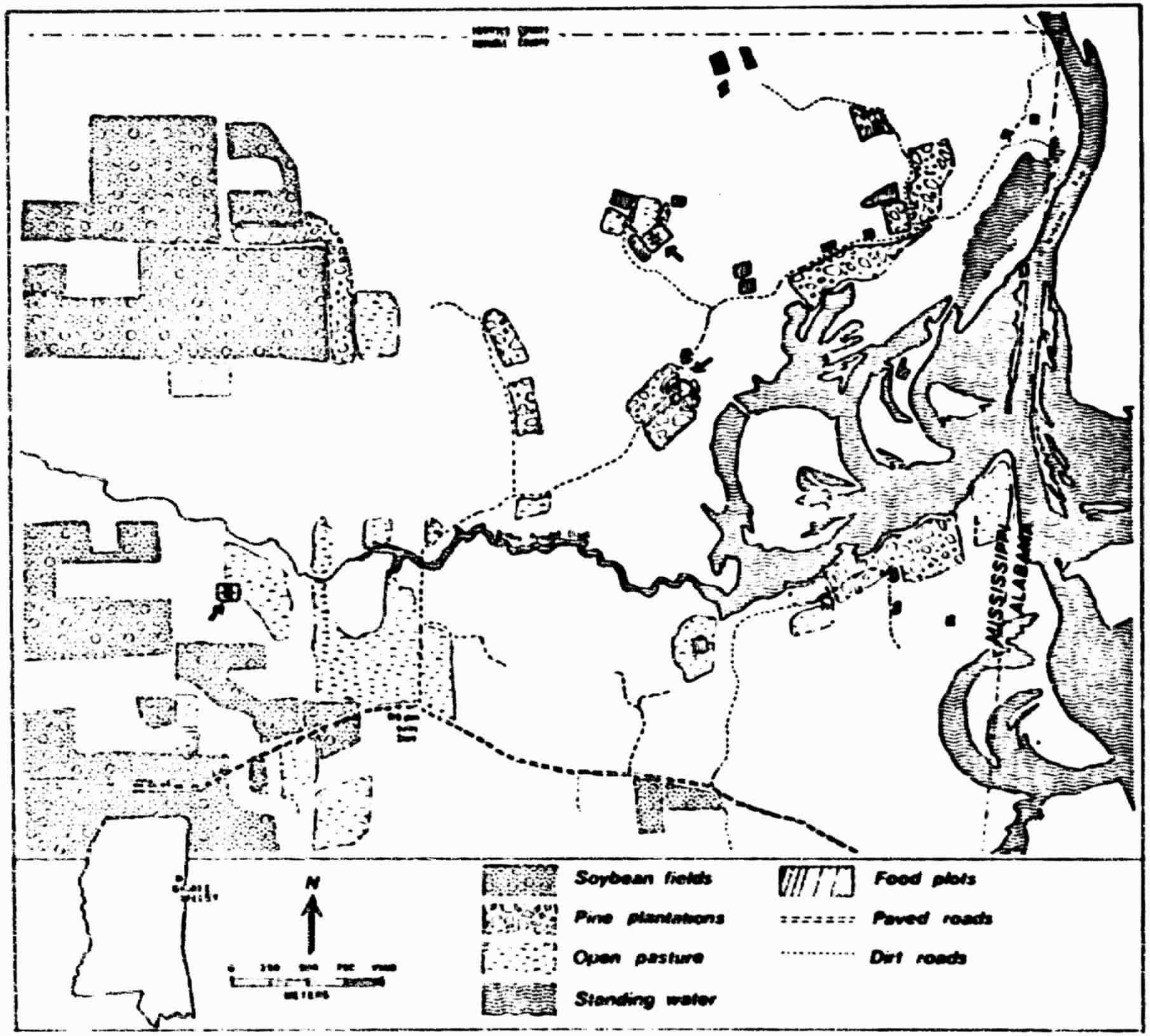

Fig. 1. Map of Bigbee Valley study area showing capture locations (*) of radio-collared deer.

MATERIALS AND METHODS

Capture and Marking

Twenty-four deer were captured using modified Stephenson box traps (Masters 1978) and drop nets (Ramsey 1968) during February and March, 1980. All deer were tagged in both ears with numbered Temple ear tags (Temple, TX). Ten deer were outfitted with radio collars (Table 1), the remainder were ear-tagged only. Movements were also noted on 4 deer which were tagged on the area during 1978-79.

Telemetry Equipment

All telemetry equipment used for the study was purchased from Telonics, Inc., Mesa, AZ. Adult deer were fitted with a 500 g unit, consisting of a butyl-rubber collar and a Telonics 5B transmitter. Units for juvenile deer consisted of break-away collars with 4A transmitters, totalling 330 g. Both units operated in the 164-166 MHz range and were powered with lithium batteries when activated by removing an external magnet. A TR-2 receiver with direct frequncy readout and a rechargable power pack were used in the study. The receiver was coupled with a TS-1 scanner-programmer to obtain scanning and memory capabilities. A RA-24 antennae, 2-element "H" type with 4dBd gain, was used for most readings. A larger 8-element

Table 1. Capture date, age and sex of white-tailed deer outfitted with radio collars at Bigbee Valley, MS (1980-81).

Capture Date	Age (months)	Sex	Transmitter Frequency (MHz)	Identification Number
2/04/80	30+	F	164.160	160
2/05/80	19	M	164.200	200
2/05/80	7	M	164.650	650[a]
2/20/80	30+	F	164.220	220
2/20/80	7	F	164.625	625[a]
2/25/80	30+	M	164.140	140
3/10/80	30+	F	164.120	120
3/13/80	19	F	164.260	260
3/18/80	7	F	164.675	675[a]
3/18/80	7	M	164.700	700[a]

[a]Fitted with juvenile break-away collars.

beam antennae was also used, but the increase in receiving range did not offset the disadvantage of unwieldiness.

Transmitter Attachment

Transmitter units were attached, activated and tested at the capture site. Collars were fitted snugly to adult does, but adult buck collars were attached less tightly to allow for neck expansion during the rut. Later observations indicated that best results were obtained when collars were fitted only as tight as necessary to prevent them from slipping over the animal's head.

Juvenile deer were outfitted with break-away collars. These collars were lined with a 2 cm-strip of foam padding and had a connecting section of surgical tubing. The tubing expanded during collar placement and was designed to deteriorate, allowing the collar to drop off after approximately 10 months of exposure to weather. The snugness caused by the foam padding and the elasticity of the tubing seemed to induce the deer to kick at the collar. Because of the expandible nature of the tubing, collars were often kicked over the deer's head. Eight juvenile deer were collared before 4 transmitter units were successfully attached.

Receiving Stations

A network of 25 receiving stations was established to track telemetered deer. Selection criteria for

receiving stations were proximity to animals being monitored, ease of access, ease of location on aerial photographs and distance from transmission lines or other sources of electromagnetic interference.

Radio-tracking Procedure

Animals were monitored for a continuous 12-hour period every 5 days for 1 year beginning 2 April 1980. The start of the 12-hour observation period was alternated between 0000 hours and 1200 hours to evenly monitor all time periods. An attempt was made to obtain 1 fix per deer every 2 hours during the observation period.

A radio fix was determined by obtaining an azimuth from at least 2 different receiving stations. Stations were chosen by considering the proximity to the animal, signal characteristics at those stations, and the angle between those stations. A 90° angle between receiving stations was considered optimum (Heezen and Tester 1967). Functional accuracy of the telemetry system was determined by placing a transmitter in several known locations. Known and calculated locations were compared; bias and error of the system were determined (Springer 1979).

At the selected stations, azimuths were obtained to the nearest degree with a Suunto compass as described by Wigley (1977). Night readings were obtained with the aid of a plastic flashlight. In all cases, care was

taken to prevent any metal objects from interfering with the compass or antennae. All telemetry and meteorological data were recorded on a standard form (Fig. 2).

On 2 occasions, it was necessary to use light aircraft to locate deer that had left the study area. A 2-element Yagi antennae was affixed to each wing strut of the plane at 45° from the line of flight and 45° below the horizontal wing surface. A switch unit allowed alternating or simultaneous use of antennas. Signals were located at altitudes of 1500 m or more and were fixed to ±0.5 ha by decreasing altitude, circling and alternating signal reception between antennas. Ground follow-ups were conducted as soon as possible after the flight to confirm locations.

Data Manipulation and Analysis

Field data were coded and punched on computer data cards. Each card represented 1 deer location and contained all the information associated with that particular fix. Cards were read into a computer file and were sorted as to deer number, time and date. Analysis was conducted by combining computer software employed for habitat description by the Mississippi Remote Sensing Center (MRSC) (under contract 14-16-0009-80-56 from the U. S. Fish and Wildlife Service through the Mississippi Cooperative Fish and Wildlife Research Unit) with TELEPRO,

DATE ______________

DEER ______________

RIVER STAGE ______________

TELEMETRY DATA
BIGBEE VALLEY, MISSISSIPPI
DEPARTMENT OF WILDLIFE AND FISHERIES
MISSISSIPPI STATE UNIVERSITY

MOON PHASE ______________
MOON RISES ______________
MOON SETS ______________
SUNRISE ______________
SUNSET ______________

FIX	TIME OF READING	TRACKING STATION	BEARING FROM O	SIGNAL STRENGTH	COORDINATES		RAIN	TEMP C	HUMID.	BAROMETRIC PRESSURE	WIND DIR.	WIND VEL.	CLOUD COVER	REMARKS
					X	Y								

Fig. 2. Data sheet used in telemetric deer study at Bigbee Valley, MS (1980-81).

a program developed at the MRSC to determine deer locations from raw telemetry data and calculate home-range and movement statistics.(Fig. 3). TELEPRO converted, by triangulation, azimuths taken in the field to map coordinates. This file could be manipulated by deer number or time and date of location. TELEM (Koeln 1979) and HOMEST (Dunn 1978) were incorporated as subroutines of TELEPRO to calculate several deer movement statistics from the map coordinates produced from the data. These statistics included home range by convex polygon (Mohr 1947), capture radius (Hayne 1949), non-circular (Jennrich and Turner 1969) and multivariate Ornstein-Uhlenbeck (MOU) (Dunn and Gipson 1977) methods; geometric center of use (Hayne 1949); mean activity radius (Dice and Clark 1953) and travel distance between points. Statistics could be calculated for any user defined time period.

Habitat analysis was conducted utilizing a digital land resource data base prepared by the MRSC. The data base, 19,000 ha centered on the study area, consists of a series of digitized files, each depicting a mapped, ecological variable created using photogrammetric methods. Color infrared imagery (scale 1:15,870) flown 25 May 1979 was used for vegetative land cover analysis. The logical structure of the data base with a listing of ecological variables is contained in the Appendix.

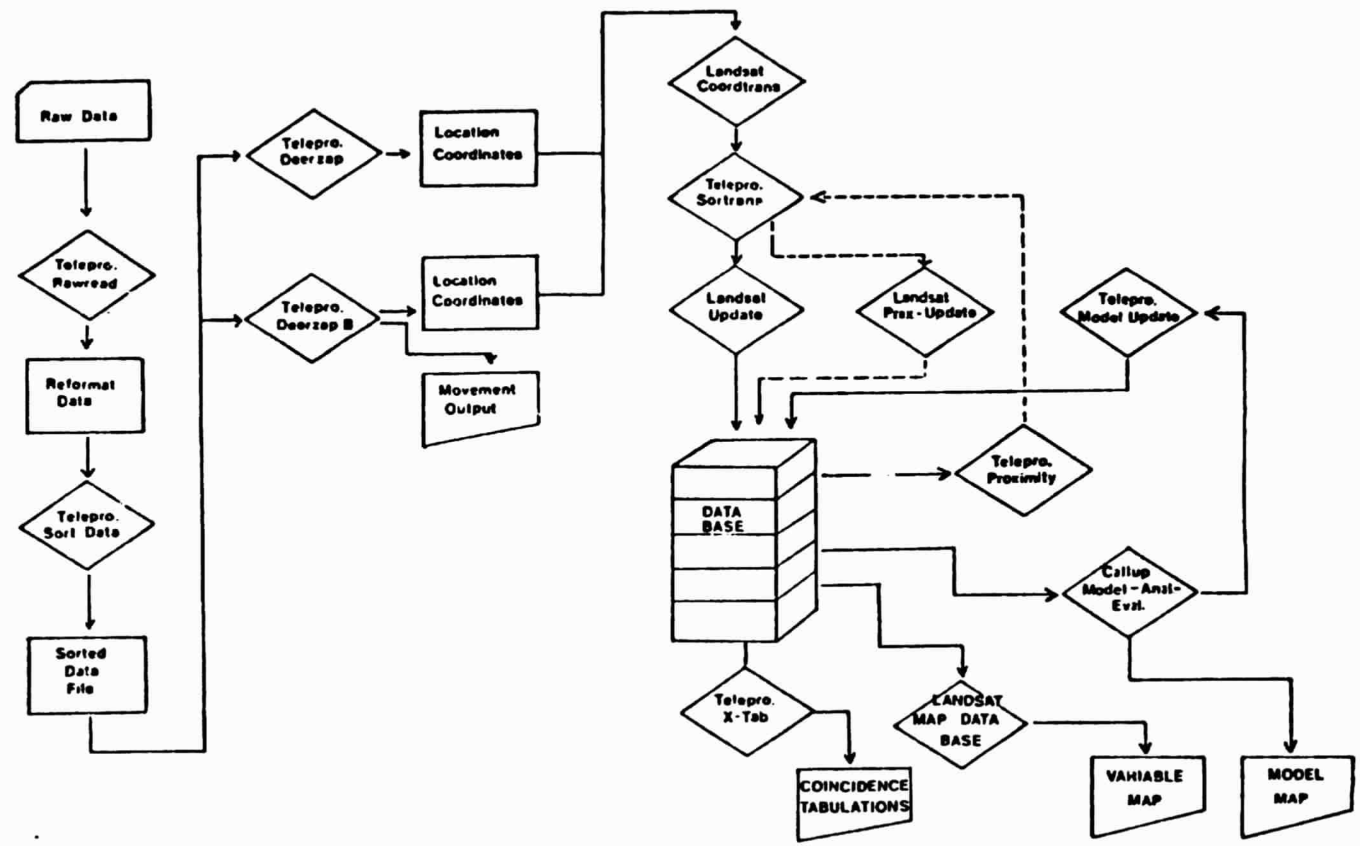

Fig. 3. Flowchart of computer software used in analysis of telemetry data from Bigbee Valley deer study (1980-81).

Map coordinates of deer locations were converted to digitized data base coordinates using operational software at the MRSC. Deer locations for specific time intervals were added to the data base as separate ecological variables. TELEPRO was used to create proximity values that measure the distance between deer locations and other features in the data base. This information was loaded into the data base so that each cell was tagged with a proximity value for each individual deer. Proximity values ranged from 0 (occurring in the same cell as a deer location) to 10 (10 or more cells to the nearest deer location). Proximity values greater than 10 could be generated if desired.

Deer locations were sorted by 4 seasons: spring (March-May), summer (June-August), fall (September-November) and winter (December-February). Deer occurrences were compared with vegetative types and proximity to agricultural lands.

Goodness of fit tests (Zar 1974) were used to determine if vegetative type availability was different from vegetative type utilization by deer (H_o: Deer use each vegetative type in proportion to its occurrence on the study area). Goodness of fit tests also were used to examine changes in vegetative type utilization by season. All goodness of fit tests were conducted using the G statistic which is considered, in most cases, to be more

appropriate than the standard Chi-square statistic (Sokal and Rohlf 1969). To eliminate bias due to differential habitat availability, an affinity index (Cairns and Telfer 1980) was calculated for each vegetative type. A Kruskal-Wallis test (Nie and Hull 1977) was used to determine if affinity index values of the various vegetative cover types were different. Utilization-availability analysis (Neu et al. 1974) was used to determine which vegetative cover types were preferred or avoided by deer.

RESULTS AND DISCUSSION

Telemetry Accuracy

Accuracy of the telemetry system and data collection procedure was evaluated by placing a transmitter at several known locations under a variety of meteorological and vegetative conditions. The 95% confidence interval for an individual azimuth was $\pm$ 7.5° of the observed value (N = 37). Thus, the error arc (Springer 1979) for each azimuth was 15°. The intersection of 2 error arcs defined an error polygon. The probability of a transmitter being located in this polygon was the probability that the transmitter was in both arcs simultaneously $(0.95)^2 = 0.9025$, or 90%. At a range of 500 m between transmitter and receiver, the area of the error polygon produced by 2 15° arcs was 1.78 ha when the observed azimuths intersected at a 90° angle.

The smallest area portrayed in the habitat data base was 0.404 ha. The accuracy of the telemetry data precluded the use of this area as a discrete deer location. The next larger unit allowed by the logical structure of the data base was 2.02 ha, larger than the calculated 1.78 ha error polygon. Thus, in the data base, each deer location was treated as a 2.02 ha area centered on the point of triangulation.

Movements

Juveniles

Due to equipment failure, data were recorded on juvenile deer for 4 months or less. The surgical tubing on 3 collars deteriorated faster than anticipated, causing premature collar loss. Deer 625 (female) crossed the Tombigbee River in late March 1980. Her collar was recovered in late April, 2.8 km from the capture site. Deer 650 (male) left the study area in May 1980. Aerial search located the animal in an agricultural area 14.4 km south of the capture site on 11 June 1980. The animal was observed in the same area 27 June 1980. On 24 July 1980, the collar was recovered near this location. Deer 700 (male) remained on the study area during the spring of 1980. His collar was recovered in July, 300 m from the capture site. This deer was killed 1 December 1980, 500 m from the capture location. Deer 675 (female) remained on the study area until July 1980. Aerial search in August and subsequent ground searches failed to locate this animal or its radio-collar. Transmitter failure was assumed.

Returns on 6 juvenile ear-tagged deer showed some moved substantial distances (Table 2), similar to dispersal movements described by Hawkins et al. (1971) and Kammermeyer and Marchington (1976). These authors

Table 2. Tag returns of white-tailed deer from Bigbee Valley, MS (1979-1981).

Date tagged	Tag numbers	Sex	Age at tagging (months)	Date killed	Distance between tag and return sites (kilometers)
2/13/79	267 268	M	7	11/23/79	0.7
2/13/79	269 270	M	7	12/79	1.6
2/23/79	275 276	M	7	11/19/79	0.0
3/06/79	293 294	F	30+	12/08/79	3.3
3/15/79	297 298	M	8	12/01/79	1.9
8/20/79	199 200	F	1	12/28/79	9.7
2/13/80	233 234	M	7	11/20/80	7.3
2/25/80	319 320	M	19	01/10/81	4.3
2/29/80	323 324	M	7	11/28/81	0.0
3/01/80	327 328	M	7	11/22/80	4.8
3/10/80	329 330	F	7	11/15/80	9.1
3/18/80	339 340	M	8	12/13/80	1.5
					$\bar{x}$ = 3.7
					s = 3.4

reported dispersal occurred principally among males just prior to or during their first breeding season, probably due to sexual competition. However, data from radio-collared deer in the present study indicated that juvenile dispersal occurred just prior to the fawning season in July. This behavior may have been triggered by antagonism of pregnant does toward their juvenile offspring as parturition approached (Downing et al. 1969, Hirth 1977).

Adults

Several of the collared adult deer made notable movements outside observed home ranges. Two of these animals, males 140 and 200, exhibited major shifts of centers of use between summer and winter. Deer 140 quit the study area in late March 1980. Aerial search located this animal 7.2 km NNE from the capture site across the Tombigbee River in Pickens County, Alabama. Subsequent monthly checks found 140 within 0.5 km of this new location. On 8 November 1980, this buck had relocated on the study area within 0.5 km of the original capture site, where he remained throughout the winter. Between March 23-28, 1981, this animal returned to the same Alabama area. Deer 200 also made shifts in home range. This buck's summer range was centered 3 km SE of its winter area. However, unlike 140, movement between

these 2 areas occurred over several weeks. Reasons for these seasonal shifts by adult males are unclear.

Activities of deer 120 (female) were centered in a small (50 ha) woodlot throughout the summer of 1980. She left this area between 30 August and 2 September 1980 and was discovered 12 km NNE. Aerial search on 9 September located her 21.6 km E of the 2 September 1980 location, 14.5 km WNW of the original home range. On 19 September, the animal reappeared on its original range, where it remained throughout the study. An area of heavy cover in the animal's woodlot was cleared 1 to 2 days prior to the late August exodus.

Deer 160 (female) left her established home range in May 1980 and moved into a 20 ha woodlot in an agricultural area 3.2 km SSE of her established center of activity. The animal stayed in this location for 5-10 days and then returned to her original location and activity patterns. No apparent cause of this behavior was identified, although this movement appeared similar to "trips" described by Inglis et al. (1979).

Movement data were also obtained from 2 adult ear-tagged deer (Table 2). The 2.5-year-old male was found dead in the Tombigbee River 4.3 km upstream from its capture site. The 2.5+-year-old female was killed on a food plot 3.3 km from its capture site.

Habitat Use

Deer locations were combined with habitat variables in the data base to determine deer utilization of the various habitat components. Utilization was defined as the relative amount of time a deer spent in each habitat component. Because data base variables were delineated in 0.404 ha units and deer locations were assigned to 2.02 ha units, each deer location could be associated with up to 5 sub-variables. Vegetative landcover was the primary variable examined. The relative availability of vegetative types and the number of various pixels associated with deer locations are summarized in Table 3.

A test for heterogeneity using the G statistic (Zar 1974) showed that the relative occurrences with vegetative-type were statistically different between deer ($p < 0.001$) (Table 4). The hypothesis that deer use each vegetative type in proportion to its occurrence was rejected for each deer at the 0.001 level (Table 4). Affinity index values are shown in Table 5. Kruskal-Wallis tests showed that the affinity index values of the various vegetative-cover types were different ($p < 0.001$).

Tables 6-11 show confidence intervals for each vegetative type used to detect disproportionate use by

Table 3. Vegetative cover type availability and white-tailed deer usage on Bigbee Valley, MS (1980-1981).

Vegetative cover type	Proportion of study area	Number pixels (Proportion of total utilization associated with deer occurrences)					
		Deer 120	Deer 140	Deer 160	Deer 200	[illegible]er 2[illegible]0	Deer 260
Pine saw dense	0.027	0	20 (0.037)	23 (0.017)	32 (0.025)	[illegible]6 ([illegible].023)	35 (0.030)
Pine saw sparse	0.007	0	22 (0.040)	0	2 (0.001)	4 (0.003)	22 (0.019)
Pine imm dense	0.049	0	23 (0.042)	49 (0.037)	26 (0.020)	86 (0.075)	109 (0.093)
Pine saw sparse	0.012	0	71 (0.130)	80 (0.059)	58 (0.045)	67 (0.059)	53 (0.045)
Hrdwd saw dense	0.362	275 (0.316)	337 (0.616)	886 (0.637)	724 (0.564)	698 (0.613)	644 (0.549)
Hrdwd saw sparse	0.068	110 (0.086)	4 (0.007)	25 (0.018)	39 (0.030)	24 (0.021)	21 (0.018)
Hrdwd imm dense	0.015	3 (0.002)	3 (0.005)	37 (0.027)	121 (0.099)	5 (0.004)	14 (0.012)
Hrdwd imm sparse	0.018	101 (0.079)	0	12 (0.009)	6 (0.005)	0	3 (0.002)
Cypress/Tupelo	0.015	0	5 (0.009)	0	1 (0.001)	10 (0.009)	25 (0.021)
Mixed saw	0.042	0	38 (0.069)	40 (0.029)	44 (0.033)	21 (0.018)	17 (0.014)
Mixed imm	0.019	0	0	0	11 (0.009)	4 (0.003)	0
Pine sap dense	0.022	0	3 (0.005)	0	0	0	0
Hrdwd sap dense	0.030	13 (0.010)	9 (0.016)	6 (0.0[illegible])	14 (0.010)	0	18 (0.015)
Hrdwd sap sparse	0.012	0	0	0	8 (0.006)	0	4 (0.003)
Row crops	0.179	203 (0.160)	12 (0.023)	152 (0.113)	167 (0.129)	133 (0.117)	132 (0.113)
Pasture	0.122	567 (0.446)	0	71 (0.053)	30 (0.023)	62 (0.054)	76 (0.065)
Total	0.999	1272	547	1361	1283	1140	1173

Table 4. Test for goodness of fit using the G statistic for white-tailed deer use of vegetative cover types at Bigbee Valley, MS (1980-81).

Deer	Observed pixel frequencies, f_i (expected pixel frequencies, F_i) by cover type.																G $(2\Sigma f_i \ln \frac{f_i}{F_i})$	df
	Pine Saw D.	Pine Saw S.	Pine Imm. D.	Pine Imm. S.	Hdwd Saw D.	Hdwd Saw S.	Hdwd Imm. D.	Hdwd Imm. S.	Cyp/ Tup. Gum	Mix Saw	Mix Imm.	Pine Sap.	Hdwd Sap. D.	Hdwd Sap. S.	Pas- ture	Row Crop		
120	0 (34)	0 (9)	0 (62)	0 (15)	275 (461)	110 (87)	3 (19)	101 (23)	0 (19)	0 (53)	0 (24)	0 (30)	13 (38)	0 (15)	203 (228)	567 (155)	1451	15
140	20 (15)	22 (4)	23 (27)	71 (7)	337 (198)	4 (37)	3 (8)	0 (10)	5 (8)	38 (23)	0 (10)	3 (12)	9 (16)	0 (7)	12 (98)	0 (67)	707	15
160	23 (37)	0 (9)	49 (63)	80 (16)	866 (465)	25 (87)	37 (19)	12 (23)	0 (19)	40 (54)	0 (24)	0 (28)	6 (38)	0 (16)	152 (230)	71 (157)	818	15
200	32 (35)	2 (9)	26 (63)	58 (16)	724 (465)	39 (87)	121 (19)	6 (23)	1 (19)	44 (54)	11 (24)	0 (28)	14 (38)	8 (16)	167 (230)	30 (157)	816	15
220	26 (31)	4 (8)	86 (56)	67 (14)	698 (413)	24 (78)	5 (17)	0 (20)	10 (17)	21 (48)	4 (22)	0 (25)	0 (34)	0 (14)	133 (204)	62 (139)	660	15
260	35 (32)	22 (8)	109 (57)	53 (14)	644 (426)	21 (80)	14 (18)	3 (21)	25 (18)	17 (49)	0 (22)	0 (26)	18 (35)	4 (14)	132 (210)	76 (143)	518	15
Pooled	136 (183)	510 (48)	293 (332)	329 (81)	3544 (2453)	223 (461)	183 (102)	122 (122)	41 (102)	160 (285)	15 (129)	3 (149)	60 (204)	12 (82)	799 (1213)	806 (827)	2021	15
Total G																	4960	90
Heterogeneity G (Total G - pooled G with total df - pooled df)																	2939 ($p < 0.001$)	75

Table 5. Vegetative cover affinity index values for white-tailed deer on Bigbee Valley, MS (1980-1981).

Vegetative cover types	Affinity index values					
	Deer 120	Deer 140	Deer 160	Deer 200	Deer 220	Deer 260
Pine saw dense	0	1.350	0.626	0.924	0.845	1.110
Pine saw sparse	0	5.750	0	0.223	0.501	2.680
Pine imm dense	0	0.858	0.735	0.414	1.540	1.900
Pine imm sparse	0	10.800	4.900	3.760	4.900	3.770
Hrdwd saw dense	0.597	1.700	1.760	1.560	1.690	1.520
Hrdwd saw sparse	1.270	0.106	0.270	0.447	0.310	0.263
Hrdwd imm dense	0.157	0.366	1.810	6.290	0.292	0.796
Hrdwd imm sparse	4.410	0	0.490	0.260	0	0.142
Cypress/Tupelo	0	0.609	0	0.052	0.585	1.420
Mixed saw	0	1.650	0.700	0.817	0.439	0.345
Mixed imm	0	0	0	0.451	0.185	0
Pine sap dense	0	0.249	0	0	0	0
Hrdwd sap dense	0.341	0.548	0.147	0.364	0	0.512
Hrdwd sap sparse	0	0	0	0.520	0	0.284
Pasture	0.892	0.123	0.624	0.727	0.652	0.629
Rowcrops	3.650	0	0.428	0.192	0.446	0.531

Table 6. Relative occurrence of deer 120 on 15 vegetative cover types at Bigbee Valley, MS (1980-81).

Type	Proportion of total area (p_o)	Proportion observed (p_i)	95% confidence interval on p_i
	Number of fixes = 254		
Pine saw dense	.027	0	-[a]
Pine imm dense	.049	0	-[a]
Pine imm sparse	.012	0	-[a]
Hdwd saw dense	.362	.216	$.140 \leq p_i \leq .292$[c]
Hdwd saw sparse	.068	.086	$.034 \leq p_i \leq .138$
Hdwd imm dense	.015	.002	-[a]
Hdwd imm sparse	.018	.079	-[a]
Cypress/Tupelo	.015	0	-[a]
Mixed saw	.042	0	-[a]
Mixed imm	.019	0	-[a]
Pine sap dense	.022	0	-[a]
Hdwd sap dense	.030	.010	-[a]
Hdwd sap sparse	.012	0	-[a]
Pasture	.179	.160	$.317 \leq p_i \leq .183$
Rowcrops	.122	.446	$.415 \leq p_i \leq .477$[c]
Grouped[b]	.261	.091	$.038 \leq p_i \leq .144$[c]

[a]Observed proportion was too small for calculation of confidence interval.

[b]Combination of vegetative types with small observed proportions.

[c]Indicates significant difference between estimated and hypothesized occurrence.

Table 7. Relative occurrence of deer 140 on 15 vegetative cover types at Bigbee Valley, MS (1980-81).

Type	Proportion of total area (Po)	Proportion observed (p_i)	95% confidence interval on p_i
	Number of fixes = 109		
Pine saw dense	.027	.037	$0.0 \le p_i \le .091$
Pine imm dense	.049	.042	$0.0 \le p_i \le .099$
Pine imm sparse	.012	.130	$.034 \le p_i \le .226$[c]
Hdwd saw dense	.362	.616	$.478 \le p_i \le .755$[c]
Hdwd saw sparse	.068	.007	-[a]
Hdwd imm dense	.015	.005	-[a]
Hdwd imm sparse	.018	0	-[a]
Cypress/Tupelo	.015	.009	-[a]
Mixed saw	.042	.069	$0.0 \le p_i \le .142$
Mixed imm	.019	0	-[a]
Pine sap dense	.022	.005	-[a]
Hdwd sap dense	.030	.017	-[a]
Hdwd sap sparse	.012	0	-[a]
Pasture	.179	.022	-[a]
Rowcrops	.122	0	-[a]
Grouped[b]	.378	.065	$.006 \le p_i \le .136$[c]

[a]Observed proportion was too small for calculation of confidence interval.

[b]Combination of vegetative types with small observed proportions.

[c]Indicates significant difference between estimated and hypothesized occurrence.

Table 8. Relative occurrence of deer 160 on 15 vegetative cover types at Bigbee Valley, MS (1980-81).

Type	Number of fixes = 272		
	Proportion of total area (p_o)	Proportion observed (p_i)	95% confidence interval on p_i
Pine saw dense	.027	.017	-[a]
Pine imm dense	.049	.036	$.003 \le p_i \le .069$
Pine imm sparse	.012	.059	$.017 \le p_i \le .101$[c]
Hdwd saw dense	.362	.636	$.550 \le p_i \le .722$[c]
Hdwd saw sparse	.068	.018	$0.0 \le p_i \le .042$[c]
Hdwd imm dense	.015	.027	$0.0 \le p_i \le .056$
Hdwd imm sparse	.018	.009	-[a]
Cypress/Tupelo	.015	0	-[a]
Mixed saw	.042	.029	$0.0 \le p_i \le .059$
Mixed imm	.019	0	-[a]
Pine sap dense	.022	0	-[a]
Hdwd sap dense	.030	.004	-[a]
Hdwd sap sparse	.012	0	-[a]
Pasture	.179	.112	$.055 \le p_i \le .169$[c]
Rowcrops	.122	.052	$.012 \le p_i \le .092$[c]
Grouped[b]	.143	.030	$.001 \le p_i \le .061$[c]

[a]Observed proportion was too small for calculation of confidence interval.

[b]Combination of vegetative types with small observed proportions.

[c]Indicates significant difference between estimated and hypothesized occurrence.

Table 9. Relative occurrence of deer 200 on 15 vegetative cover types at Bigbee Valley, MS (1980-81).

Type	Proportion of total area (p_o)	Proportion observed (p_i)	95% confidence interval on p_i
	Number of fixes = 257		
Pine saw dense	.027	.025	$0.0 \le p_i \le .054$
Pine imm dense	.049	.020	$0.0 \le p \le .046$[c]
Pine imm	.012	.045	$.007 \le p_i \le .083$
Hdwd saw dense	.362	.564	$.472 \le p_i \le .656$[c]
Hdwd saw sparse	.068	.030	$0.0 \le p_i \le .061$[c]
Hdwd imm dense	.015	.094	$.040 \le p_i \le .148$[c]
Hdwd imm sparse	.018	.005	-[a]
Cypress/Tupelo	.015	.001	-[a]
Mixed saw	.042	.034	$.001 \le p_i \le .067$
Mixed imm	.019	.009	-[a]
Pine sap dense	.022	0	-[a]
Hdwd sap dense	.030	.011	-[a]
Hdwd sap sparse	.012	.006	-[a]
Pasture	.179	.130	$.068 \le p_i \le .192$
Rowcrops	.122	.023	$0.0 \le p_i \le .051$[c]
Grouped[b]	.116	.032	$0.0 \le p_i \le .064$[c]

[a]Observed proportion was too small for calculation of confidence interval.

[b]Combination of vegetative types with small observed proportions.

[c]Indicates significant difference between estimated and hypothesized occurrence.

Table 10. Relative occurrence of deer 220 on 15 vegetative cover types at Bigbee Valley, MS (1980-81).

Type	Proportion of total area (p_o)	Proportion observed (p_i)	95% confidence interval on p_i
	Number of fixes = 222		
Pine saw dense	.027	.023	$0.0 \leq p_i \leq .053$
Pine imm dense	.049	.075	$.023 \leq p_i \leq .127$
Pine imm sparse	.012	.059	$.0122 \leq p_i \leq 106$[c]
Hdwd saw dense	.362	.612	$.515 \leq p_i \leq .709$[c]
Hdwd saw sparse	.068	.021	$0.0 \leq p_i \leq .049$[c]
Hdwd imm dense	.015	.004	-[a]
Hdwd imm sparse	.018	0	-[a]
Cypress/Tupelo	.015	.009	-[a]
Mixed saw	.042	.018	-[a]
Mixed imm	.019	.004	-[a]
Pine sap dense	.022	0	-[a]
Hdwd sap dense	.030	0	-[a]
Hdwd sap sparse	.012	0	-[a]
Pasture	.179	.117	$.053 \leq p_i \leq .181$[c]
Row crops	.122	.054	$.009 \leq p_i \leq .099$[c]
Grouped[b]	.173	.035	$0.0 \leq p_i \leq .072$[c]

[a]Observed proportion was too small for calculation of confidence interval.

[b]Combination of vegetative types with small observed proportions.

[c]Indicates significant difference between estimated and hypothesized occurrence.

Table 11. Relative occurrence of deer 260 on 15 vegetative cover types at Bigbee Valley, MS (1980-81).

Type	Proportion of total area (p_o)	Proportion observed (p_i)	95% confidence interval on p_i
	Number of fixes = 254		
Pine saw dense	.027	.030	$0.0 \leq p_i \leq .062$
Pine imm dense	.049	.093	$.039 \leq p_i \leq .147$
Pine imm sparse	.012	.045	$.006 \leq p_i \leq .084$
Hdwd saw dense	.362	.549	$.457 \leq p_i \leq .641$[c]
Hdwd saw sparse	.068	.018	-[a]
Hdwd imm dense	.015	.012	-[a]
Hdwd imm sparse	.018	.003	-[a]
Cypress/Tupelo	.015	.021	$0.0 \leq p_i \leq .048$
Mixed saw	.042	.014	-[a]
Mixed imm	.019	0	-[a]
Pine sap dense	.022	0	-[a]
Hdwd sap dense	.030	.015	-[a]
Hdwd sap sparse	.012	.003	-[a]
Pasture	.179	.113	$.054 \leq p_i \leq .172$[c]
Rowcrops	.122	.065	$.019 \leq p_i \leq .111$[c]
Grouped[b]	.226	.065	$.019 \leq p_i \leq .111$[c]

[a]Observed proportion was too small for calculation of confidence interval.

[b]Combination of vegetative types with small observed proportions.

[c]Indicates significant difference between estimated and hypothesized occurrence.

individual deer following the technique described by Neu et al. (1974). Several confidence intervals could not be computed because either n (number of observations) or p_i (proportion observed) was not sufficiently large, using the rule of thumb np_i; or $n(1-p_i) = 5$ (Hayes and Winkler 1970). These proportions that were excessively small were grouped and 1 confidence interval was computed for the combined types (Tables 6-11). After examining the various confidence intervals, types that were used disproportionately by deer were further tested to detect seasonal differences in utilization. Confidence intervals (95%) were computed for proportions of use of each type by season, then compared with the theoretical 0.25 per season. Differences in utilization between seasons were rarely significant.

Three vegetative types, sparse immature pines, row crops and dense mature hardwoods were clearly used disproportionately by all the study deer. All adult deer with the exception of 120 exhibited a preference for the sparce immature pine type. This preference was significant ($p < 0.05$) for deer 140, 160 and 220. No seasonal differences in utilization were detected. Sparse immature pines were found in plantations and accounted for less than 2% of the total study area. The combination of regular prescribed burning and incomplete crown closure would be expected to yield an abundance of deer foods

(Halls 1973). Heavy growths of blackberry (Rubus spp.), greenbrier (Smilax spp.), Japanese honeysuckle (Lonicera japonica) and sweetgum (Liquidambar styraciflua) sprouts were found in the sparse immature pine type. Apparently, crown closure is an important feature in this type. Areas of dense immature pine were more than 4 times as abundant as sparse immature pine, but were not used significantly. Crown closure has been shown to be an important factor in deer food production in pine plantations (Stransky and Halls 1967, Blair 1967).

Row-cropped areas, principally soybeans, accounted for over 10% of the study area. Only 1 deer, 120, utilized this type significantly ($p < 0.05$) more than expected. All other deer under-utilized this type ($p < 0.05$). No seasonal preferences were detected in deer 120. While deer utilization of cropland was low overall, summer use of these areas was apparent. Most deer increased their utilization of soybean areas in the summer although this increase was significant ($p < 0.05$) for deer 260 only. It appears that most deer utilize soybeans when available, but to varying degrees.

Dense mature hardwoods covered 36% of the study area. Use of this type by the collared deer was found to be significant ($p < 0.05$) except in 1 case. Deer 120 was found in this type significantly ($p < 0.05$) less than expected. No seasonal differences in utilization of this

type were found. This type is similar in composition to "bottomland hardwoods," a habitat widely recognized as good deer habitat (Moore 1967, Stransky 1969, Zwank et al. 1979). Yields of acorns and other hard mast would be expected to attract deer in the fall and winter. The results of this study, however, suggest that deer are attracted to bottomland hardwoods year-round. It has been reported that well-watered hardwood bottoms contain deer forage superior to other sites (Moore et al. 1960, Moore 1967, Segelquist and Green 1968). The combination of browse and mast may explain the year-round attractiveness of bottomland hardwoods to the collared deer in this study. However, the sparse mature hardwoods type, where incomplete crown closure would be expected to increase deer food production, was used significantly ($p < 0.05$) less than expected by several deer. Reasons for this differential utilization of the 2 hardwood types are unclear.

Of the remaining vegetative types, most accounted for only small portions (≤ 0.02) of the study area or of deer utilization. Deer use of these combined types was significantly less ($p < 0.05$) than expected. This is probably due more to deer selecting preferred vegetative types than to avoidance of the under-utilized types. The remaining major vegetative type, pasture, which accounted for almost 18% of the study area, was

under-utilized by deer. Under-utilization of this type was probably due to a lack of concealing cover and the presence of large numbers of cattle. Antagonistic behavior of cattle toward deer was observed during the conduct of this study.

Home Range

Home range was defined as the area which included 95% of an animal's activities (Jennrich and Turner 1969). The multivariate Ornstein-Uhlenbeck diffusion process was considered to be the most appropriate method for home-range estimation using radio-telemetry data (Dunn and Gipson 1977, Tucker and Kroll 1981). Independence of individual fixes was not a necessary assumption for this method since the movements of each animal are treated as Markovian (a continuous path).

The 3 home-range calculation methods used in this study produced large home-range estimates, ranging from 238 ha to 4002 ha (Tables 12-14). Home-range sizes varied between seasons. While most deer showed increases in home range during the summer, deer 120 showed a home-range increase in the winter. The especially large spring home-range estimate for deer 160 is partially due to the 10 day trip taken by this animal in May. The trip-like movements of deer 120 and 140 were not reflected in home-range estimates because these movements were outside the system of established tracking stations.

Table 12. Multivariate Ornstein-Uhlenbeck home-range estimates (ha) by season for 6 white-tailed deer, Bigbee Valley, MS (1980-81).

Deer	Spring (March-May)	Summer (June-Aug.)	Fall (Sept.-Nov.)	Winter (Dec.-Feb.)
120	625	398	718	1041
140	-	-	-	807[a]
160	2120	1116	668	729
200	1126	-[b]	1041	526
220	-[b]	1011	1209	266
260	365	1112	692	521

[a]Home range estimated for 12 November 1980 - 28 March 1981.

[b]No estimate available as process did not appear stationary.

Table 13. Non-circular home-range estimates (ha) by season for 6 white-tailed deer, Bigbee Valley, MS (1980-81).

Deer	Spring (March-May)	Summer (June-Aug.)	Fall (Sept.-Nov.)	Winter (Dec.-Feb.)
120	948	354	747	1028
140	-	-	-	699[a]
160	3797	1519	764	1304
200	1018	1693	827	578
220	1097	1306	921	238
260	643	1342	622	514

[a]Home range estimated for 12 November 1980 - 28 March 1981.

Table 14. Convex polygon home-range estimates (ha) by season for 6 white-tailed deer, Bigbee Valley, MS (1980-81).

Deer	Spring (March-May)	Summer (June-Aug.)	Fall (Sept.-Nov.)	Winter (Dec.-Feb.)
120	1413	370	630	1195
140	-	-	-	1411[a]
160	4002	2533	812	2846
200	1089	1364	520	585
220	1266	1306	998	329
260	842	1343	863	707

[a]Home range estimated for 12 November 1980 - 28 March 1981.

Home-range increases in deer 220 and 260 appeared related to increased utilization of soybeans during the summer months. Home-range size increased concurrently with the number of occurrences in soybean fields and a shift of geometric centers (1100 m and 600 m respectively) of use toward these fields. Deer 160 and 200 also shifted their centers of use nearer to soybean fields during the summer; however, coincident increase in soybean utilization was not as large as that seen in deer 220 and 260.

Deer 120 was the only animal whose geometric center of use was located in an agricultural rather than forested area. Accordingly, summer home range for deer 120 was smallest of the 4 seasonal home ranges, while winter home range was the largest. A shift in center of use, 600 m nearer to bottomland habitat, also was observed in the winter home range of deer 120. This shift reflected deer 120's apparent strategy for exploiting the available habitat. This strategy centered activity around agricultural areas most of the year, with farther ranging in the winter when food was less plentiful in the fields. Another possible strategy was exhibited by deer 160, 200, 220 and 260. They appeared to center most activity in hardwood areas where mast was plentiful in fall and winter and where succulent new vegetation was available in spring. During the summer when these foods

were scarce, these animals ranged farther and increased their utilization of agricultural areas. Deer 140 centered his activity in bottomlands during the winter and made long movements in March to a swamp adjoining agricultural lands. Lack of sufficient radio fixes during April-October prohibited home range and utilization estimates. Seasonal home-range expansion and resulting changes in vegetative-cover utilization seemed to coincide with the theory that deer in Mississippi undergo 2 stress periods each year, summer and late winter (Jacobson et al. 1981). Multiple strategies for habitat exploitation have been observed in deer on the Welder Wildlife Refuge in Texas (Inglis et al. 1979).

Observations of tagged and unmarked deer indicated that numerous animals subscribe to both proposed strategies. It should be noted that deer 120 was the only adult radio-collared animal captured close to agricultural areas. The other 5 adults were captured at sites closer to the river bottom (Fig. 1). These capture site locations may explain the disproportionate ratio of the 2 strategies exhibited by radio-collared animals.

Most studies of white-tailed deer in the Southeast have reported home-range estimates of less than 200 ha (Michael 1965, Marchington and Jeter 1966, Byford 1969, Wigley 1977, Inglis et al. 1979, Tucker and Kroll 1981).

A possible explanation for the large sizes of home-range estimates found in the present study is habitat diversity. The Bigbee Valley area includes several distinct categories of vegetative cover, soils and topography. Deer may have found it advantageous to maintain large home ranges in order to fully exploit the habitat.

SUMMARY AND CONCLUSIONS

Deer were found to utilize bottomlands areas, especially mature hardwood stands, extensively throughout the year. Other vegetative types, notably soybean fields and open pine plantations, were attractive to deer but did not displace bottomland hardwoods as the overall most utilized type.

The results of this study concur with those of Zwank et al. (1979), finding that bottomland hardwoods are heavily used by white-tailed deer year-round. Soybeans are attractive to deer but seasonal forage provided by soybeans does not offset the permanent loss of hardwoods often caused by agricultural clearing. Efforts to stem clearing of remaining bottomland hardwood tracts should be pursued.

Seasonal differences were noted in home range size and geometric centers of use. A possible explanation of these differences and the large estimates of home-range size involves the diversity of the area. In order to effectively utilize the available habitat, deer appear to move so as to exploit various segments of the habitat as they become most attractive. Soybeans are a seasonally attractive resource utilized to varying degrees by individual deer. Two strategies

for habitat utilization were observed. One strategy called for a center of activity in agricultural areas and home range expansion during winter months. The other strategy made use of hardwood areas as the center of activity, with summer expansion of home range to include some agricultural lands.

Long-range movements were observed in both adult and juvenile deer. Juvenile movements appeared to be dispersal activity, while adults always returned to previously occupied areas.

The seasonal movements and large home ranges described in this study have significant management implications. Most apparent is the conflict between deer and soybean farmers. The fact that some deer shift their range to utilize soybean fields may cause concentrations of deer in agricultural areas, resulting in depredation problems. Farmers often feel deer cause a significant economic loss and consequently pressure state wildlife officials for depredation permits. Issuance of these permits reduces the number of deer available to hunters in the fall. In areas where deer depredation is a chronic problem, hunters and farmers should be educated and encouraged to increase antlerless harvest over the appropriate area.

Other management problems may result from extensive deer movements. Recently, many sportsmen in

Mississippi have shown interest in improving the quality of the deer herds they hunt. Potential managers should know the minimum area that can be effectively and economically managed for deer herd improvement. Most sportsmen are apprehensive about undertaking a management plan when results may be threatened by excessive deer immigration or emmigration. In the past, deer managers have often quoted approximately 4100 ha (10,000 acres) as the minimum area necessary for effective deer management. Results of this study indicate that a larger area may be required for intensive, quality deer management, especially in areas with significant habitat diversity.

Computer analysis of telemetry data coupled with digital habitat data bases provide a useful and economic tool for analysis of animal/habitat interactions. The use of digital data bases and telemetry data should be expanded to answer specific questions concerning animal/ habitat relationships. This study dealt with utilization of vegetative types by deer; however, utilization was defined as occurrence only. The questions of when and to what extent deer use various habitat components has been addressed in part; questions regarding how and why should follow. At each location in an animal's environment, variables such as vegetation, soil, slope, proximity to water, etc. interact to produce a unique habitat. Discriminant analysis, radio-telemetry and

computer modelling techniques could be combined to describe these interactions and develop habitat suitability values. Once these methods are established and applied, large areas of wildlife habitat could be inventoried and evaluated inexpensively. The resulting data base would provide managers with the information needed to evaluate the impact of land-use decisions on wildlife.

APPENDIX

Appendix Table 1. Logical structure of the Bigbee Valley data base.

Variable		Sub-Variables
1	Transportation	0 void 1 paved 2 gravel 3 jeep trails
2	Water	0 void 1 first order channels 2 second order channels 3 third order channels 4 lakes, sloughs, ponds
3	Topography	0 water 1 120-130 ft 2 130-140 ft 3 140-150 ft 4 150-160 ft 5 160-180 ft 6 180-200 ft 7 200-220 ft 8 220-240 ft 9 240-260 ft 10 260-300 ft
4	Landcover[a]	0 void 1 pine saw dense 2 pine saw sparse 3 pine imm dense 4 pine imm sparse 5 hrdwd saw dense 6 hrdwd saw sparse 7 hrdwd imm dense 8 hrdwd imm sparse 9 cypress/tupelo gum 10 mixed sawtimber 11 mixed immature 12 pine sapling dense 13 pine sapling sparse 14 hrdwd sapling dense 15 hrdwd sapling sparse

[a]dense-greater than 60% crown closure
sparse-less than 60% crown closure
saw-sawtimber, 10.5" dbh
imm-immature, 2"-10.5" dbh
sap-sapling, less than 2" dbh

Appendix Table 1. Continued.

Variable	Sub-Variables
5 Landcover (cont.)	0 void 1 pasture 2 row crops 3 residential/coml sites 4 open water
6 Soils	0 void 1 Vaiden/Sessums 2 Brooksville/Okolona 3 Sumter/Savannah (eroded) 4 Caledonia 5 Smithdale 6 Prentiss 7 Guyton/Stough 8 Cahaba/Latonia/Leeper/ Catalpa 9 Cahaba and Latonia 10 Leeper/Jena/Mantachie
7 Proximity to paved roads	0 feature in cell 1 1 cell from paved road 2 2 cells from paved road 3 3 cells from paved road 4 4 cells from paved road 5 5 cells from paved road 6 6 cells from paved road 7 7 cells from paved road 8 8 cells from paved road 9 9 cells from paved road 10 10 cells from paved road 11 11 cells from paved road 12 12 cells from paved road 13 13 cells from paved road 14 14 or more cells from paved road
8 Proximity to gravel roads	0 feature in cell 1 1 cell from light road 2 2 cells from light road 3 3 cells from light road 4 4 cells from light road 5 5 cells from light road 6 6 cells from light road 7 7 cells from light road 8 8 cells from light road 9 9 cells from light road

Appendix Table 1. Continued.

Variable	Sub-Variables
8 Proximity to gravel roads (continued)	10 10 cells from light road 11 11 cells from light road 12 12 cells from light road 13 13 cells from light road 14 14 or more cells from light road
9 Proximity to dirt roads	0 feature in cell 1 1 cell from dirt road 2 2 cells from dirt road 3 3 cells from dirt road 4 4 cells from dirt road 5 5 cells from dirt road 6 6 cells from dirt road 7 7 cells from dirt road 8 8 cells from dirt road 9 9 cells from dirt road 10 10 cells from dirt road 11 11 cells from dirt road 12 12 cells from dirt road 13 13 cells from dirt road 14 14 cells or more from dirt road
10 Proximity to first order streams	0 feature in cell 1 1 cell from first order stream 2 2 cells from first order stream 3 3 cells from first order stream 4 4 cells from first order stream 5 5 cells from first order stream 6 6 cells from first order stream 7 7 cells from first order stream 8 8 cells from first order stream 9 9 cells from first order stream 10 10 cells from first order stream

Appendix Table 1. Continued.

Variable	Sub-Variables
10 Proximity to first order streams (continued)	11 11 ells from first order stream
	12 12 cells frim first order stream
	13 13 cells from first order stream
	14 14 or more cells from feature
11 Proximity to second and third order streams	0 feature in cell
	1 1 cell from feature
	2 2 cells from feature
	3 3 cells from feature
	4 4 cells from feature
	5 5 cells from feature
	6 6 cells from feature
	7 7 cells from feature
	8 8 cells from feature
	9 9 cells from feature
	10 10 cells from feature
	11 11 cells from feature
	12 12 cells from feature
	13 13 cells from feature
	14 14 or more from feature
12 Proximity to row crops	0 feature in cell
	1 1 cell from row crops
	2 2 cells from row crops
	3 3 cells from row crops
	4 4 cells from row crops
	5 5 cells from row crops
	6 6 cells from row crops
	7 7 cells from row crops
	8 8 cells from row crops
	9 9 cells from row crops
	10 10 cells from row crops
	11 11 cells from row crops
	12 12 cells from row crops
	13 13 cells from row crops
	14 14 or more cells from row crops

Appendix Table 1. Continued.

Variable	Sub-Variables
13 Proximity to pasture	0 feature in cell
	1 1 cell from pasture
	2 2 cells from pasture
	3 3 cells from pasture
	4 4 cells from pasture
	5 5 cells from pasture
	6 6 cells from pasture
	7 7 cells from pasture
	8 8 cells from pasture
	9 9 cells from pasture
	10 10 cells from pasture
	11 11 cells from pasture
	12 12 cells from pasture
	13 13 cells from pasture
	14 14 or more cells from pasture

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